

Egg parasitoids of the glassy-winged sharpshooter in California

This article is designed for individuals interested in understanding and roughly identifying the most important natural enemies of the glassy-winged sharpshooter. Although the article is fairly detailed, it is written for the layperson and formal identification should not be made solely using the information contained in this document. There are several excellent papers and researchers listed at the end of the article that should be referred to if more formal identification is required.

Egg Parasitoids

The name egg parasitoid is used to describe an insect that parasitized the eggs of another insect. This life cycle is typical to many insects: the adult female, upon finding a suitable egg, inserts her own eggs into the host eggs. The parasitoid eggs hatch and the developing larvae devour the host's eggs before pupating and emerging as an adult, mating, and going on to search for more host eggs. Many parasitoids can control the sex of their offspring. As the host eggs are laid in groups, usually only one male is laid for several females; the sole role of the male is to mate with as many females as possible. The female parasitoid has to search for more host eggs and food to stay alive as long as possible.

Parasitoids are frequently the organism of choice for biological control programs. The main reason for this is that they tend to be fairly specific; in other words attacks on non-target species (e.g., native or beneficial insects) can be kept to a minimum. Predators are less frequently used because of difficulties in ascertaining the full range of prey species.

GWSS Egg Parasitoids Native to California

The glassy-winged sharpshooter, *Homalodisca coagulata* (Say), was first reported in California in the late 1980s when it was collected from citrus trees in Ventura County. Following the arrival of GWSS, a number of native egg parasitoids were identified emerging from GWSS eggs in California.

The existence of egg parasitoids native to California that can successfully parasitize GWSS is due to the presence of the smoketree sharpshooter (STSS) in California. This insect was mistakenly called *Homalodisca lacerta* but has recently been re-identified as *Homalodisca liturata*. The range of STSS is rather strange; it is predominately a desert adapted insect and is not considered a serious agricultural pest. There are, however, several populations found in coastal areas of California. Also, STSS population explosions can occur, probably as a function of particular climatic conditions.

There are at least six species of native egg parasitoids that can use GWSS as a host (Table 1). They can be divided into two families, the Trichogrammatidae and the Mymaridae. There are two species of Trichogrammatidae. They are very small ($<1/32''$), usually black and produce many holes in each egg as they emerge from their host. The two species are very hard to discriminate and are rarely found in California beyond desert areas. Studies at UC Riverside (PI: Joseph Morse) found both species unsuitable for use as augmentative biological control agents. They are very hard to rear, accept only very freshly laid eggs, and most commonly parasitize host eggs laid in non-agricultural plants. Several other trichogrammatid species have been collected from eggs in SE USA and NE Mexico, but none were selected for use as biological control agents in California.

The most successful family of GWSS egg parasitoids is the Mymaridae. Until recently, all species have been in the genus *Gonatocerus*. Most Mymaridae can successfully parasitize GWSS eggs until a day or two before the GWSS nymph emerges (usually 5 days out of the 7 day egg development period). Except for two species, a single parasitoid emerges ($1/16''$) from each GWSS egg cutting a neat round hole as it emerges. If a GWSS egg mass is not parasitized; the nymphs emerge from the cut edge of the leaf that their mother made when inserting the eggs so no holes are made.

The sex of Mymaridae can be distinguished by the shape of the antennae: female have clubbed tips while the males have long whip-like antennae. All descriptions below refer to the female of each species as these are the most likely to be encountered.



Gonatocerus ashmeadi is the most common species of GWSS egg parasitoid in California. This insect is considered to be native to SE USA and NE Mexico, although the parasitoid has been present in California at least since the late 1970s and may have been accidentally introduced with this pest. Female *G. ashmeadi* are black with what looks like a yellow and black striped abdomen (actually the abdomen is swollen with eggs so that the pigmented shell of the insect is separated by a transparent membrane). They are found emerging from eggs laid on all host plants throughout the year. Parasitism rates can be as high as 95% of eggs parasitized, but parasitism rates drop to below 25% after winter. The parasitoid has been found throughout the GWSS range in California.



Gonatocerus morrilli is the next most common species. This insect is slightly larger than *G. ashmeadi*, is yellow, and the female has two white antennal segments. The insect can be as common as *G. ashmeadi*, especially in coastal areas (San Diego, Orange, Los Angeles, and Ventura Counties). The insect is found further inland but at much lower levels. This insect is actually a complex of at least two species; research at UC Riverside (Stouthamer) and USDA Agricultural Research Service (de Leon) will clarify the status of these species.

Gonatocerus incomptus and ***Gonatocerus novifasciatus*** are slightly smaller than *G. ashmeadi* and are totally black. The latter has a slightly dark patch on the forewing; a specialist should make accurate identification of these species. These remaining two native mymarid species are fairly rare and are most frequently observed early and late in the year. Other species of *Gonatocerus* may be found in California; these could be extremely rare native species or opportunistic exotic species.

Egg parasitoids Introduced to California

The California Department of Food and Agriculture in association with the University of California, Riverside and the USDA-ARS in Weslaco, Texas, started introductions of exotic biological control agents into California in 2000. To date, all species introduced have come from North America. The first three species were introduced in 2000. These were *Gonatocerus triguttatus*, *G. ashmeadi*, and a species from the *G. morrilli* complex. The latter two species are already present in California (see above). The introduction of these two species is an attempt to introduce new genetic stock into the preexisting California populations with the aim of improving the natural enemies' ability to find, and successfully parasitize GWSS.



Gonatocerus triguttatus was collected from several locations in the southeastern U.S. and northeastern Mexico where it is a common GWSS egg parasitoid. This insect is the same color as *G. morrilli* but its antennae have no white antennal segments; it is actually more related to *G. ashmeadi* but is mostly yellow. Since releases were started, over 700,000 *G. triguttatus* have been released in California and over 150 GWSS egg masses collected in the field have been identified as being parasitized by *G. triguttatus*.



Gonatocerus fasciatus was first released in 2001 after it had been collected earlier in the year in Louisiana. In its native range, this insect appears earlier than other species. All other *Gonatocerus* species produce one offspring from each GWSS egg; *G. fasciatus* can produce up to seven offspring from each egg. The result is that, at low egg density levels, this species can build up numbers much more rapidly than other species. Later in the season this insect is out competed by other species in this genus. The insect looks like a smaller version of *G. ashmeadi* but with a more amber tan yellow colored abdomen. The insects usually cut two holes, one at each end of each GWSS egg, when they emerge; this differs from the other *Gonatocerus* species that cut only one hole per egg.

Anagrus epos was collected in Minnesota in 2004. It is minute ($<1/32''$) and up to 14 offspring has been recorded as emerging from a GWSS egg. This species successfully parasitizes a number of other genera including *Homalodisca*. *Anagrus epos* has three desirable attributes that may favor it as an effective biological control agent in California.

The insect can overwinter; that is undergo a diapause phase during the winter so that it does not emerge when host egg masses are absent. It has a very high potential reproductive rate due to its ability to produce multiple offspring from each GWSS egg. The insect is also able to parasitize at least one other sharpshooter genus in California. The latter is particularly important; it may be possible to release this insect prior to the occurrence of GWSS in some areas so that there is a non-apparent control measure in place should the insect arrive. The parasitoid may also be a potential candidate for use as a biological control agent against native sharpshooter and leafhopper species that transmit plant diseases. Full host range studies are underway at the University of California, Riverside (PI: Joseph Morse).

Some confusion exists regarding the identity of *A. epos* and closely related species. A number of species of *Anagrus* exist in California and they are very hard to differentiate; all could be mistaken for yellow thrips to the untrained eye. Seven years ago, Serguei Triapitsyn (UC Riverside) described 9 species of *Anagrus* associated with grapevine agroecosystems in North America. Species from the *Anagrus* genus collected in California include *A. atomus*, *A. erythroneuræ*, *A. daanei*, *A. nigriventris*, and *A. avalae*. The true *A. epos* is not considered to be native to California, although it was introduced as an agent against the variegated leafhopper during 1986-1988. While the insect could have established temporarily, the possible establishment does not appear to have been permanent and has not been documented. No recent records have identified *A. epos* in California and, of the more than 10,000 egg masses that have been examined by the CDFA and UCR, none have been parasitized by *Anagrus*.

Species	Native to California	Introduced to California	Comments
Mymaridae			
<i>Anagrus epos</i> Girault	No	Yes	New introduction
<i>Gonatocerus ashmeadi</i> Girault	?Yes/?No	Yes	Common in CA, FL, LA, TX, NE Mexico
<i>Gonatocerus fasciatus</i> Girault	No	Yes	Common early in LA
<i>Gonatocerus incomptus</i> / <i>impar</i> complex*	Yes	No	Uncommon
<i>Gonatocerus morrilli</i> complex *	Yes	Yes	Common in coastal CA
<i>Gonatocerus novifasciatus</i> Girault	Yes	No	Uncommon
<i>Gonatocerus triguttatus</i> Girault	No	Yes	Common in TX, Mexico
Trichogrammatidae			
<i>Ufens principalis</i> Owen	Yes	No	Desert adapted, hard to rear
<i>Ufens ceratus</i> Owen	Yes	No	Desert adapted, also occurs in humid areas, hard to rear

* Species complex: a group of several morphologically similar species.

Researchers involved in GWSS egg parasitoid studies:

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Gonatocerus biology. Biological control of GWSS in Tahiti. Natural enemies of native sharpshooters. Risk assessment to native sharpshooters

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Biology of *Anagrus epos*. Biological control of GWSS in citrus groves.

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Exploration for GWSS egg parasitoids, establishment of colonies in quarantine, morphological taxonomy of GWSS egg parasitoids

Selected Publications Regarding GWSS Egg Parasitoids

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- de León, J. H. & W. A. Jones (2005). Genetic differentiation among geographic populations of *Gonatocerus ashmeadi*, the predominant egg parasitoid of the glassy-winged sharpshooter, *Homalodisca coagulata*. 9pp. *Journal of Insect Science*, 5:2, Available online: insectscience.org/5.2
- de León, J. H., W. A. Jones & D. J. W. Morgan (2004). Molecular distinction between populations of *Gonatocerus morrilli*, egg parasitoids of the glassy-winged sharpshooter from Texas and California: Do cryptic species exist? 7pp. *Journal of Insect Science*, 4:39, Available online: insectscience.org/4.39
- de León, J. H., W. A. Jones, S. Setamou, & D. J. W. Morgan (2005). *Gonatocerus morrilli* (Hymenoptera: Mymaridae), a primary egg parasitoid of the glassy-winged sharpshooter (*Homalodisca coagulata*) exists in nature as a cryptic species complex. Submitted.
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- Logarzo, G., S. V. Triapitsyn & W. A. Jones. 2004 (2003). New host records for two species of *Gonatocerus* (Hymenoptera: Mydaridae) egg parasitoids of proconine sharpshooters (Hemiptera: Clypeorrhyncha: Cicadellidae) in Peru. *Florida Entomologist*:**86**(4): 486–487.
- Logarzo, G. A., E. G. Virla, S. V. Triapitsyn & W. A. Jones (2004). Biology of *Zagella delicata* (Hymenoptera: Trichogrammatidae), an egg parasitoid of the sharpshooter *Tapajosa rubromarginata* (Hemiptera: Clypeorrhyncha: Cicadellidae) in Argentina. *Florida Entomologist* **87**(4): 511-516.
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- Triapitsyn, S. V. An annotated key to the fairyfly (Hymenoptera: Mymaridae) egg parasitoids of proconiine sharpshooters (Hemiptera: Cicadellidae: Proconiini) in the Nearctic region, with description of two new species of *Gonatocerus* Nees from California. In preparation.
- Triapitsyn, S. V. (1998). *Anagrus* (Hymenoptera: Mymaridae) egg parasitoids of *Erythroneura* spp. and other leafhoppers (Homoptera: Cicadellidae) in North American vineyards and orchards: a taxonomic review. *Transactions of the American Entomological Society* **124**(2): 77-112.
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